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ABSTRACT

There are many ways in which science can be made culturally relevant: archeoastronomy, mathematics, geology, ethnobotany, chemistry, and art can all be taught from a perspective celebrating the accomplishments of Mexican American and American Indian science and encouraging exploration. A culturally relevant curriculum provides teachers with resource materials and approaches allowing them to enable students to: develop pride in their culture's contribution to science, learn science from a familiar cultural base, be motivated to consider science as a career, and recognize the importance of science in their life. A joint project between the Society for the Advancement of Chicanos and Native Americans in Science and the Project for Renewed Incentives in Science and Education in Los Angeles (California) is developing workshops to introduce teachers to culturally relevant materials and specific activities that can be used at different grade levels. Topics include Archeoastronomy, Maya Mathematics and Calendar, Geology, Feeding the World--Productivity of Food Plants, Herbal Medicine/Ethnobotany, Science and Creativity in the Diego Rivera Murals in Detroit, Botany and Mesoamerican Designs, and the Chemistry of Color. As science is stimulated, students typically not attracted to science careers will be more aware, and the differences in participation rate of minorities in science and engineering may increase. (JMM)

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ERIC DIGEST

MEXICAN AMERICAN EDUCATION

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IMPROVING THE SCIENCE AND MATHEMATIC ACHIEVEMENT OF MEXICAN AMERICAN STUDENTS THROUGH CULTURALLY RELEVANT SCIENCE

The underrepresentation of minorities in science, mathematics, and engineering has been well documented, and in a recent workshop convened by the Research Council to review both the statistical trends of minority participation in science and engineering and the body of research that seeks to explain the differences in the participation rate of minorities, the issues were again reviewed in depth. While more research is needed, especially on Hispanics, the factors considered to be impediments to minority students' pursuit of coursework in these areas have been identified as centering around the degree of compatibility between home, community, and school environments/experiences. Suggested interventions frequently mention better preparation in mathematics and science at the elementary and secondary school levels and increasing the number or intervention programs. The success of intervention programs is well established but better preparation is usually interpreted as more science and matn classes and, to some extent, the specific subject matter that should be taught. What needs examining is what strategies a classroom teacher can use to help Mexican American students excel in the mathematics and science disciplines. This digest will explore the use of a culturally relevant curriculum as one strategy.

What Is Culturally Relevant Science?

Culturally relevant science employs materials based on the culture and history of the minority or ethnic group to illustrate scientific principles and the methodology of science already in the school's science curriculum. Because culturally relevant science is anthropological and historical in nature, it is interdisciplinary, and such science can be either taught or reinforced outside the science curriculum.

Why Is A Culturally Relevant Curriculum Needed?

Our schools assume that Hispanic and American Indian cultures are either anti-scientific or, at best, a-scientific. Concurrently, our schools commonly believe that the Western cultural heritage is particularly propitious to scientific development. Most of the material available on the development of science as well as the science curriculum taught in school reflects this ethnocentric orientation. The scientific contributions of China, India, and Islam are usually minimized and traditional native cultures are usually depicted as permeated with superstition and magic and not oriented toward science. The failure of Mexican American and American Indian children to take math and science, as well as the small number of minority scientists, can then be blamed on a deficiency in their own culture, thus exculpating the schools and the larger society from any responsibility. The factors usually examined therefore do not include failure of the schools to provide a culturally relevant curriculum. A small body of literature does, however, focus on the importance of teaching culturally relevant science (or ethnoscience) and provides specific examples of a culturally relevant curriculum.

In order for Mexican American and American Indian children to develop an interest in science and consider it as a career, there is a need to teach it using a wider diversity of examples from different cultures. This will send a message to the minority child that "my ancestors or people like me did engage in scientific endeavors, and thus I can do it too."

What Does A Culturally Relevant Curriculum Aim To Accomplish?

The aim is to provide teachers with resource material and approaches which will enable students:

1. to develop pride in their culture's contribution to science,
2. to learn science from a familiar cultural base,
3. to find a motivation to consider science as a career, and
4. to recognize the importance of science in their lives.

Is Culturally Relevant Material Considered Science?

The scientific validity of the beliefs of native peoples and the rationality of their thinking process needs to be examined carefully. We should not be trapped by an excessively restrictive definition of what constitutes science, for the definition one chooses will determine what is and what is not considered science. Malinowski (*Magic, Science and Religion*. New York: Doubleday, 1954, p. 34), for example, proposed conceiving of science as "a body of rules and conceptions, based on experience and derived from it by logical inference, embodied in material achievements and in a fixed form of tradition and carried on by some sort of social organization." He found that many principles of native knowledge were scientific by this definition. Therefore, using culturally relevant material can enhance the scope of science taught.

What Culturally Relevant Resource Materials Are Available To Teachers?

The following are examples of culturally relevant materials developed from a rich, but essentially untapped resource. These examples have been used successfully in the classroom from the primary grades through college. A joint project between The Society for the Advancement of Chicanos and Native Americans in Science (SACNAS) and the Project for Renewed Incentives in Science Education in Los Angeles (Project RISE-LA) at UCLA is developing teacher workshops to introduce teachers to culturally relevant materials and to provide them with specific activities that can be done at different grade levels. SACNAS videotape presentations which present the background necessary to implement the materials in the classroom will soon be available, as well as a series of activities and strategies for the classroom teacher. The project is being funded by the Carnegie Foundation. The examples marked with an * will indicate those in the project.

*Archeoastronomy**

The growing and popular field of archeoastronomy has provided new information as to how ancient civilizations perceived the heavens. Selected sites in the United States (the mounds of the Midwest, the medicine wheels of the Plains States, and Fajada Butte in Chaco Canyon, New Mexico) and in Mesoamerica (Teotihuacan, the Caracol at Chichen Itza, and Building J at Monte Albán) can be used for teaching astronomy, observational skills, scientific methodology, and basic mathematics. Astronomy is especially adaptable to primary school science.

Maya Mathematics and Calendar

The most sophisticated examples of Mayan thought are exemplified by their calendar and the mathematics which preceded it. Many years of astronomical observation and meticulous recordkeeping were necessary to achieve the accuracy which they attained. The structure of the calendar was determined by both their cosmological beliefs and by the nature of the mathematical system itself. Because of its complexity, the use of the calendar in the lower grades is limited.

Teaching the Mayan mathematical system is especially appropriate for the primary grades. Mayan mathematics were *vigesimal*, i.e., with powers of base 20 rather than base 10 as in the decimal system. They also employed place value notation and were one of only two cultures to independently discover the use of zero. The European knowledge of zero came through contact with Islamic culture at the end of the Middle Ages. The Arabs in turn had learned this concept in India, where it had been discovered some years after the discovery of the same principle by the Mayans in the New World. The Mayan system uses only three symbols to represent numbers, a ( ) for one unit, a (–) for five units and a ( ) for zero.

Several articles have appeared on the use of the Mayan system for arithmetic calculations. George Sanchez, the pioneer in this area, taught this system to school children in Austin, Texas and claimed that, with a small amount of instruction, they could perform arithmetic operations faster in Mayan than in the decimal system, particularly if they used an abacus arrangement. In the classroom, Mayan arithmetic can be used to illustrate the concept of place notation in a more dramatic fashion than with a decimal system and it can illustrate the concept of expressing numbers as powers of different bases, especially if it is used in conjunction with the base 2 used in computer language. It also gives a graphic illustration of the concept of borrowing and carrying from one register to another in addition and subtraction. It can be used to get children to deal comfortably with numbers in different systems, to have them play with numbers, and in general to demonstrate that mathematics can be fun. Sanchez recommended that the operations be carried out with counters (a nickle for a bar, a penny for a dot, and a bottle cap or pebble for zero) because he found that focusing on the visual patterns and carrying out the intermediate operations as one goes on, rather than writing them, is the real secret to rapid and easy calculations.

Geology

Volcanic activity has always been a fact of life in Mesoamerica. This interesting phenomenon may be used to teach basic concepts in geology while studying culture and geography. The trade items of the Mesoamericans were of volcanic origin and/or of plate margin activity (obsidian, basalt, serpentine, and jade). The cenotes (sinkholes in limestone) can be used as a starting point for the study of the geological phenomenon of underground rivers and the composition of land in Yucatan. Geology is particularly well suited for interdisciplinary study.

*Feeding the World: Productivity of Food Plants**

Agriculture, botany-ethnobotany, and nutrition come together to provide the basis for looking at a world problem—HUNGER. There is no better way to get students interested than starting out with a social issue.

The different uses and sources of many plants can be discussed with particular attention to how the Indian civilizations have contributed to food resources. Many of the practices used today in agriculture have their basis in Indian practices; in fact, we may be returning to a modified version of them today. The Aztecs developed chinampas (built up platforms on shallow lakes which were drought-proof and could produce several crops a year). Many of their foods show promise for relieving protein shortages and assisting in reducing the energy cost of agriculture. These new (for us) and unusual food plants can be used as a starting point to discuss the productivity and photosynthetic activity of food plants, their nutritional value, the food production policies of different countries, and what is being done to exacerbate world hunger.

*Herbal Medicine/Ethnobotany**

The chemistry and uses of herbal medicines can be used to teach students research strategies which involve literature searches, written reports, personal videotape interviews of friends and relatives, and designing questionnaire instruments to elicit appropriate information. At the higher grade levels, laboratory research techniques can be taught, such as chromatography of plant extracts showing students how chemical components of complicated mixtures can be isolated. These valuable research methods will be needed by the students in their future scientific studies or in their work in other disciplines. At the same time, students will be learning about the development of cultural medicine and its relevance to their own cultural lives.

In teaching classification, ethnobotanical classifications should also be presented.

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These are logical and their nomenclature is descriptive of the plant rather than a reflection of the name of the discover, as is too often the case in Linnean classification. One can point out that a classification scheme is used because a group of people agree to use it as a standard. The Linnean system is European folk biology elevated by agreement to a science and perfected over the past 200 years. Students can be encouraged to develop their own taxonomic system in order to teach them the logic of the process involved.

The one area that has received some attention in the school curriculum is ethnic foods, but in many cases it has not been used to transmit nutritional information. Much information on this is available from the Cooperative Extension Service in all land grant institutions, since it is used in their Expanded Food and Nutrition Program in all states, or from the Extension Service, U.S. Department of Agriculture, Washington, D.C.

How Can Art Be Used to Teach Science?

There are a number of ways to use art to teach science. Two areas have been well developed. The "Chemistry of Color" is still in the developmental stages.

Science and Creativity in the Diego Rivera Murals in Detroit

In the Detroit murals, Rivera placed a special emphasis on the positive and negative aspects of science and technology. He depicts the applied sciences of surgery, pharmacy, agriculture, chemistry, and weaponry. His representation of theoretical science extends back to the ancient Greek concepts of Earth, Fire, Air and Water and proceeds through the 19th century debate in geology over the role of fire and water to the 20th century discussion of the origin of life and the mechanism for the synthesis of life. These murals, and Rivera's art in general, can be used in the teaching of geology, biology, chemistry/biochemistry, medicine, and technology, either as a starting point for discussion or for enrichment and integrative purposes in discussing the similarities and differences between the creative processes in science and in art. While this area is part of the SACNAS-RISE-LA project, the book by McMeekin and a slide set of murals are available for purchase at the Detroit Institute of Art. Rivera murals can also be found in other parts of the United States and field trips can be arranged in these areas. The project intends to be able to provide slides of these other murals or suggest to teachers how they may prepare their own for class use.

Botany and Mesoamerican Designs

Designs on small clay spindle whorls and stamps found in some archeological excavations in Mesoamerica reveal a variety of floral and fruit structures. Spindle whorls (malacates) are 2-5 cm diameter clay discs from the bottom of the spindle used for spinning maguey, cotton or wool fibers. The stamps are 1-23 cm long incised clay artifacts probably used to print designs on another surface. The designs closely resemble sections of fruit (pepper, squash and tomato), and radially symmetrical botanical diagrams of flowers. Class activities in biology can begin with an art project. These designs can be used to learn flower structure, to learn floral diagrams, to observe various fruits in sections, to compare Mesoamerican designs with European floral diagrams, to discuss whether or not the representatives from each culture are of the same objects, and to learn which of the examples of the fruits were domesticated in the "new world."

The Chemistry of Color

Dyes from native plants can be extracted for beginner's chemistry to study color and color production. The plants can be grown or collected and classified into groups using different criteria. The dyes extracted can then be used in an art project.

Further information about resources can be procured from the various scholars working in this new field - individuals such as D.I. Marinez (Natural Science, Michigan State University-Archaeoastronomy), B. Ortiz de Montellano (Anthropology, Wayne State University - general information), W. Velez (Mathematics, University of Arizona - Mayan Math), E. Rodriguez (Developmental and Cell Biology, University of California at Irvine -ethnobotany), J. Spielberg (Anthropology, Michigan State University - Diego Rivera's art), and M. Zavala (Biochemistry, Michigan State University -Mesoamerican Botany).

Summary

There are many ways in which science can be made culturally relevant. Archeoastronomy, mathematics, geology, ethnobotany, chemistry, and art all can be taught from a perspective which celebrates the accomplishments of Mexican American and American Indian science and encourages exploration. As interest in science is thereby stimulated, students who have typically not been attracted into scientific careers will undoubtly perceive that they, too, have new possibilities.

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and

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Geology

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classification. One can point out that a classification scheme is used because a group of people agree to use it as a standard. The Linnean system is European folk biology elevated by agreement to a science and perfected over the past 200 years. Students can be encouraged to develop their own taxonomic system in order to teach them the logic of the process involved.

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There are a number of ways to use art to teach science. Two areas have been well developed. The "Chemistry of Color" is still in the developmental stages.

Science and Creativity in the Diego Rivera Murals in Detroit*

In the Detroit murals, Rivera placed a special emphasis on the positive and negative aspects of science and technology. He depicts the applied sciences of surgery, pharmacy, agriculture, chemistry, and weaponry. His representation of theoretical science extends back to the ancient Greek concepts of Earth, Fire, Air, and Water and proceeds through the 19th century debate in

geology over the role of fire and water to the 20th century discussion of the origin of life and the mechanism for the synthesis of life. These murals, and Rivera's art in general, can be used in the teaching of geology, biology, chemistry/biochemistry, medicine, and technology, either as a starting point for discussion or for enrichment and integrative purposes in discussing the similarities and differences between the creative processes in science and in art. While this area is part of the SACNAS-RISE-LA project, the book by McMeekin and a slide set of murals are available for purchase at the Detroit Institute of Art. Rivera murals can also be found in other parts of the United States and field trips can be arranged in these areas. The project intends to be able to provide slides of these other murals or suggest to teachers how they may prepare their own for class use.

Botany and Mesoamerican Designs*

Designs on small clay spindle whorls and stamps found in some archeological excavations in Mesoamerica reveal a variety of floral and fruit structures. Spindle whorls (malacates) are 2-5 cm diameter clay discs from the bottom of the spindle used for spinning maguey, cotton or wool fibers. The stamps are 1-23 cm long incised clay artifacts probably used to print designs on another surface. The designs closely resemble sections of fruit (pepper, squash and tomato), and radially symmetrical botanical diagrams of flowers. Class activities in biology can begin with

an art project or end with an art project. These designs can be used to learn flower structure, to learn floral diagrams, to observe various fruits in sections, to compare Mesoamerican designs with European floral diagrams, to discuss whether or not the representations from each culture are of the same objects, and to learn which of the examples of the fruits were domesticated in the "new world."

The Chemistry of Color

Dyes from native plants can be extracted for beginner's chemistry to study color and color production. The plants can be grown or collected and classified into groups using different criteria. The dyes extracted can then be used in an art project.

Further information about resources can be procured from the various scholars working in this new field - individuals such as D.I. Marinez (Natural Science, Michigan State University- Archaeoastronomy), B. Ortiz de Montellano (Anthropology, Wayne State University - general information), W. Velez (Mathematics, University of Arizona - Mayan Math), E. Rodriguez (Developmental and Cell Biology, University of California at Irvine - ethnobotany), J. Spielberg (Ahthropology, Michigan State University - Diego Rivera's art), and M. Zavala (Biochemistry, Michigan State University - Mesoamerican Botany).

Summary

There are many ways in which science can be made culturally relevant. Archeoastronomy, mathematics, geology, ethnobotany, chemistry, and art all can be taught from a perspective which celebrates the accomplishments of Mexican American and American Indian science and encourages exploration. As interest in science is thereby stimulated, students who have typically not been attracted into scientific careers will undoubtedly perceive that they, too, have new possibilities.

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